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SUBJECT:

DATE 3 December 1965

TO: ☐ LIFE SCIENCES ☐ BIOASTRONAUTICS ☐ SURGEON

I. BIOMEDICAL SCIENCES

A. Applied Human Physiology

1. Stress Fatigue and Measurements: Current investigations underway are largely directed toward an investigation of those static and dynamic physiologic response parameters which hold promise for giving an indication of physical fitness and stamina. These are principally carried out on a semi-annual basis, the most complete studies being done at either the Lovelace Foundation or at the Flight Medical Laboratory School of Aviation Medicine on an annual basis. Attempts are being made to carry a portion of these investigations into the actual operational and training environment but thus far our correlation of data with objective measures of mission performance is somewhat equivocal. Future efforts in this area of research should be considerably augmented. Current work in the area of stress physiology being carried out

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by the Army, Navy, Air Force and NASA is being closely followed but thus far the results of these programs have not yielded anything of value which we might apply to our operational requirement.

2. Metabolic and nutritional: As a corollary to (1) above, we are attempting in a rather crude way to determine metabolic expenditures as a function of operational and training missions; at the same time determining optimal and minimal nutritional requirements for both routine and emergency situations. High caloric-low residue diets, similar to those that NASA has developed for the astronauts, are being evaluated for our specific operational use although our particular pressure suit requirements for the most part rely upon liquid foods.

3. Diurnal Physiologic Rhythms: Since the pattern of our operational activities involves flights taking off around the clock, it is important that

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we be able to re-cycle and re-condition our pilots in a manner that is practically the reverse of their normal work-rest cycle. Our experience thus far would indicate that a period of three to four days, during which the individual is re-cycled into a night work period and a day's sleep period, is required and this does not appear to have any deleterious effects upon the individual. However we have noticed that there appears to be some individual variation on the rapidity and total effectiveness with which he can be successfully re-cycled. Whether or not these variations in individual ability to re-adapt oneself to a night-day work-rest cycle is related in any way to other physiologic adaptive processes i.e., heat, cold, reduced atmospheric pressure, etc., poses an interesting question for us but obviously not one which we are capable of resolving under field

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conditions. It is conceivable that biochemical determinations may provide us with a clue to the amount of stressful reaction an individual demonstrates in being re-cycled in this manner and also it may be possible to determine the optimal point of his re-adaptation to this abnormal work-rest cycle. This area of work needs considerable expansion during the next several years since it is closely related to developing ultimately objective criteria of pilot fitness for demanding missions.

4. Thermoregulatory Systems: One of the inflight emergencies is concerned with a dual system failure which would reduce efficiency of the ventilating system to the pressure suit by virtue of loss of heat exchange capacity of the system at the same time the thermosheath of the aircraft has mounted rapidly. Pilot experience in subjective reporting on this problem thus far has not been consistent

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and indicates again a rather significant variation in either the pilots heat tolerance, motivation or a combination of both. Weight losses after our longest flights in which this contingency has occurred have not been significant but some pilots have stated that, in their own subjective analysis, they feel that they have undergone a significant decrement in performance. Our current activity in this area has been to optimize the capability of the cooling system and we are currently investigating the feasibility of placing an emergency backup cooling system into the aircraft. We are expecting to obtain authority to instrument one aircraft (and the suited pilot) in order to determine more accurately and objectively the nature and extent of the heat pulse and its impingement on the pilot. The question remaining insofar as applied human research is concerned is whether or not to attempt to determine more

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precisely the heat tolerance of the individual pilots by any current and acceptable methods and further, in those that show a low tolerance, whether it would be advisable to attempt to improve this through appropriate adaptive means. This latter question cannot be, in our opinion, fully resolved until a better determination is made regarding the likelihood of these severe heat envelopes to occur during operational missions.

5. Respiratory Function: We have previously pointed out that increases in oxygen consumption occur during mission periods which, because of their difficulty or intrinsic hazard, evoke a general alerting and emotional response on the part of the pilot. This same phenomenon has been observed of course by other investigators studying psycho-physiologic responses to a wide variety of occupational activities, including automobile drivers on the Los Angeles freeways. We are not particularly con-

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cerned with this phenomenon since it appears to be quite a natural one and certainly the excessive consumption of oxygen poses no problem as a function of total mission duration in our particular aircraft. We are, however, interested in the individual variation that we find both in total oxygen consumption during missions and in the extent of this heightened physiologic activity during periods of emotional stress. We would like to see further work done in this area to determine whether or not a test could be devised for programming into a ground simulator which might enable us to determine more accurately the stability or lability of overall psycho-physiologic mechanisms in response to various imposed tasks. A further extension of this work, which conceivably could have some operational use for us, would be to pre-set a pattern of circulatory and

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respiratory responses into the on-board data collection and telemetry system which when exceeded would provide a reliable indication that the pilot had gone 'too far' in depth as a result of a particular crisis for him to proceed with the mission.

6. Auditory Function and Hearing Loss: The majority of pilots, having had considerable previous experience in flying high performance aircraft, show as a group some acceptable degree of hearing loss over the higher frequency ranges. However in following the total group with suitable audiometric studies, it is apparent that hearing loss progresses more rapidly in some individuals than in others and this does not seem to be directly related either to age or hours of exposure. The routine recommendation which we perceive from the central examining clinic on these individuals, showing a 30 to 50 per cent

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hearing loss in high frequencies, is to recommend that the individual be protected from further acoustic trauma. This, of course, is a rather difficult recommendation for us to follow since he is already protected to the greatest degree that is possible for us without impairing his ability to communicate. Furthermore, it has not been evident to us that after periods of absence from our noise environment up to as long as three or four weeks, that this allows any degree of auditory recovery. We therefore feel that there does exist a fairly urgent requirement to coudvct a careful evaluation of both our noise environment and the individuals contained therein, particularly the pilots since they seem to be the ones most affected. As a corollary to this study, we would recommend also that a test be devised similar to the one that Doctor Tondor developed for the Air Force at the School of Aviation Medicine in 1949, which allowed

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him to determine whether any degree of hearing loss was actually inferential in carrying out normal radio communications.

7. Visual Apparatus: It was necessary initially, because of the pressure suit constraints, to eliminate from consideration all pilots who required corrective lenses either standard or contact type. Thus far we have not experienced any problems that had their primary basis in difficulties or deficiencies in vision. Most all of the complaints which the pilots have indirectly related to vision have their basis in completely extrinsic factors such as faceplate reflectance to certain sun angles, temporary disorientation and possibly very transient vertigo experienced during night re-fueling operations in which fixed and moving points of light must be constantly integrated with the dynamic motions of both the aircraft and the re-fueling tankers.

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These occurences fortunately have been relatively rare and have not resulted in any situation which the pilot has been unable to handle. In view of the fact that this particular situation is almost impossible to duplicate except in actual aerial re-fueling, we have not been able to obtain any more factual data than simply that which the pilot subjectively reports upon at the time of his de-briefing. With the present state of our knowledge on this particular matter of disorientation during aerial re-fueling, we are not prepared at this time to state any definite operational requirement for the institution of research work to either define the problem more objectively or subsequently to recommend any modification of the equipment involved.

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B. Toxicology

1. Closed Atmospheric Gases: Aviators breathing oxygen is utilized from both liquid and gaseous stores although the majority of our operational activities are supported by liquid oxygen sources. We rely principally upon the prescribed regulations governing the manufacture, storage and delivery of all aviator's breathing oxygen supplies and from time to time have had occasional complaints on the part of the pilots that the oxygen coming into the masks does not smell right. These specific complaints arise much more often with the liquid oxygen sources than with the gaseous and because of their infrequency have not been considered a problem. We have attempted to explore in complete detail all possibilities in the manufacture and storage of oxygen supplies, whether liquid or gaseous, in which any type of irritant or toxic product could be developed within the manufacturing process

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or inadvertently gain access as a stray contaminant. However we are not yet satisfied that we have all the data necessary on this particular aspect of toxicology and would therefore list this as a study project under this section which we would like to see initiated in the immediate future.

2. The toxicological aspects of all the various organo-metallic and chemical compounds which go into or evolve from the entire vehicular system have largely been investigated by the prime contractor but we are not aware of any single monograph which has been published by him covering the studies made and their results. Since there are a considerable number of new chemical compounds being used in this particular vehicle, it would seem incumbent upon us to collect and document the experiences gained for future reference in other similar Air Force Advanced Projects.

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3. Environmental factors which take into consideration both accidental and intended toxic infiltration of food, water and open atmospheres, including chemical, biologic and radiologic warfare agents, has thus far not been an area of concern. The integrity of our food and water supplies is largely a function of security and thus far we have had no incidents of either accidental or intended toxic contamination of these comestibles.

4. Cockpit air contamination as a function of component malfunction in flight has been rather extensively studied and investigated by the prime contractor along with some extrapolated estimates of ozone concentrations during prolonged flight at maximum operating altitudes. From these studies and estimates it has been concluded that no hazard exists from either of these two possible sources.

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C. Radiobiology

1. Dosage and Dosimetry: Past experience with aircraft flying at similar altitudes and at equivalent latitudes in which reasonably accurate dosimetric measurements were made, both on the aircraft and the pilot, have indicated that no significant hazard from ionizing radiation events exists both in terms of acute or chronic biologic effects. It is quite difficult to give an exact figure for an average exposure dose imposed upon a pilot flying at maximum altitude at a northerly latitude but it would probably be fairly safe to say that in the absence of a significant solar flare, the total dose received would be no greater than ten to fifteen millirads over an eight to ten hour mission period. While we are in an operational sense quite comfortable and secure with our current

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estimates, we nevertheless would emphasize this area of investigation for future active prosecution in order to define the radiobiological factor much more precisely than it exists at the present time.

2. Acute and chronic biologic effects have not been studied on our pilots principally for the reasons given in (1) above. We did do a questionnaire survey to bring out long-term genetic effects on a small pilot population which has been flying for a period of from eight to ten years at altitudes in excess of 50,000 feet. The results of this study did not support in any way the premise that chronic genetic effects could be demonstrated in a higher degree of this pilot group than in the standard population. However since this study was made better methods of studying white blood cell aberrations have been introduced principally in the form of cariotyping which appears to be sensitive to quite small chronic accumulated

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doses of ionizing radiation over normal background. Therefore we are strongly in support of instituting these additional studies on both the new and the older continuing project pilots.

3. Protection in Prophylaxis: Under our current operational situations and assigned flight profiles, there is no situation under which a crew member could receive an acute incapacitating dose of ionizing radiation. Therefore no work in this area of radiobiology is being sponsored by OSA at the present time. However future programs could conceivably pose a problem of crew exposure to an artificially induced radiation environment of an intensity to cause acute symptoms to appear. Therefore work on this problem currently being sponsored by other governmental agencies is being followed and extracted for future reference.

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II. BEHAVORIAL SCIENCES

A. Personal Factors in Selection

1. Individual Assessment: At the present time our problems of selecting individual applicants for duties requiring a high degree of skill, motivation, courage and physical stamina is somewhat minimized by the fact that all of them have considerable past experience in flying high performance aircraft. Therefore the procedures used are largely routine as regards psychiatric interviews and projective psychological testing, all of which have thus far provided us with a very high success to failure ratio of accepted applicants. However, because of the very significant amount of expense and effort involved in the selecting and training of these applicants for special projects, we are constantly striving toward a matrix of procedures which would practically guarantee us 100% success. Dr. George Ruff, of the University of Pennsylvania Medical School, has been working for the past two years

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on a modified isolation test which gives considerable promise of indicating more accurately the individual quotient of motivation and we recommend that this effort be continued and possibly expanded.

2. Group Behavior and Interactions: Opportunities to carry out studies on group behavior, interactions and interpersonal relationships are minimal and only a cursory type of study is possible under the conditions of their compressed schedule during the induction period. However in the hands of competent psychologists, using a free open-ended association under conditions of relaxed informal environment, a good correlation has been found between the estimates made at the end of these small group sessions with the individual assessments made during the other interview and testing procedures. We do not feel that this particular effort merits future R and D work since it does not appear feasible to devote any more time than is currently available to this particular aspect of our selection procedures.

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3. Family and Social Backgrounds: A certain amount of information on the social, economic and family patterns of behavior are available through records and indirect, discreet inquiries. However one of the most important factors in a candidates selection is that of his wife's personality and behavorial pattern, particularly as it relates to vagaries in demands of his assigned duties. Under the current restraints of security, it is possible only to evaluate this consort factor on an indirect basis through questions to the candidate himself, and although honest answers are probably given, nevertheless an accurate evaluation and prediction of future behavior on the part of the wife under the actual conditions of the assignment cannot be made. Our experience has not been particularly traumatic in the past as a result of serious psychological or behavioral problems developing in the wife or family. At the same time, it would appear highly desirable in terms of future selection procedures, to develop a method by which a more accurate personality evaluation can be made on the wife and family.

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B. Training and Evaluation

1. Assessment of Skills and Aptitudes Directly Pertaining to System Requirements: Thus far in Special Projects the transition into an advanced prime vehicle has largely been a function of greater speed and altitude and therefore considered as being a direct extension of those skills and aptitudes required to fly conventional high performance aircraft. It is largely felt that this concept is quite valid with the possible exception of imposing a functional requirement upon the pilot for integrating subsystems inputs and indicators in a manner or pattern opposite to any similar procedure which he had learned in the past.

2. Training Methodology, Devices and Simulators: An early decision to leapfrog the use of any special training devices and/or simulators, going directly to the use of a two-phase 'training version' of the basic aircraft, raised some problems during the

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early portion of the operational test and evaluation phase in that the degree of pilot overloading was difficult to evaluate. However as greater reliability was realized in the various subsystems, and ultimately into the total system, the probability of serious overloading of the pilot during critical phases of the mission was significantly reduced. Despite current optimistic views on this question, we would reccommend that some type of procedural trainer or simulator be mocked-up to provide a more accurate time-motion study of pilot performance on the longer and more complicated missions.

3. Before evaluation of performance, no formal methodology or procedures have been evolved thus far in this program to critically evaluate performance and instead, the traditional means of evaluation against mission effectiveness on an individual basis has been used. The pilot is routinely evaluated

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from an aeromedical standpoint before and after each mission but no attempt has been made thus far to integrate these findings with the objective measures of mission effectiveness. We would reccommend that some effort be committed in 1966 to this area of investigation.

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